DTU Library

Arrangements of a pair of loudspeakers for sound field control with double-layer arrays

Chang, Jiho; Agerkvist, Finn T.; Olsen, Martin

Published in:
Proceedings of AES 52nd International Conference: Sound Field Control - Engineering and Perception

Publication date:
2013

Citation (APA):
Chang, J., Agerkvist, F. T., & Olsen, M. (2013). Arrangements of a pair of loudspeakers for sound field control with double-layer arrays. In *Proceedings of AES 52nd International Conference: Sound Field Control - Engineering and Perception* (pp. 258-261). [6-2] Audio Engineering Society.

Development of a pair of loudspeaker for sound field control with double-layer arrays

Abstract

Recent studies have attempted to control sound fields, and also to reduce room reflections with an array of loudspeakers. One of the attempts is to suppress sound waves propagating to the walls with double-layer arrays of loudspeakers. The distance between these layers should be shorter than the half-wavelength, but in practice this condition is occasionally hard to satisfy because of the sizes of loudspeakers. This study aims to develop a pair of loudspeakers that has short distance between the acoustic centers at low frequencies. The effect of diffraction of sound waves due to the enclosure of the other loudspeaker is examined with simulations, and a pair of loudspeakers is proposed.

Precis

Recent studies have attempted to control sound fields and also to reduce room reflections at the same time with an array of loudspeakers. Most of these methods for sound field control have been developed in free-field condition, and the reflections can degrade performances in practice. Listening rooms are normally treated with sound absorption materials, but it is still hard to achieve enough sound absorption at low frequencies. One of the attempts to solve this problem is to suppress sound waves propagating to the walls, the ceiling, and the floor. In theory, this suppression is possible if a listening region is surrounded by continuous monopoles and dipoles based on the Kirchhoff-Helmholtz integral equation. The continuous monopoles and dipoles can be realized with double-layer of discrete loudspeakers that are independently driven at low frequencies where the loudspeakers behave as monopoles. That is, each pair of the loudspeakers represents a combination of monopoles and dipoles that are controllable on the condition that the distance between these two layers is much shorter than the wavelength.

In practice, however, it is hard to satisfy this condition because of the sizes of loudspeakers. For example, one of the recent studies has used closed-box loudspeakers that are mounted back-to-back [Chang and Jacobsen, J. Acoust. Soc. Am. 131 (6), 4518-4525, 2012]. The length of the loudspeakers is 15 cm, and the distance between the diaphragms is 30 cm. At low frequencies where a loudspeaker behaves as a monopole, it has been well known that the center of the monopole is in front of the diaphragm, which is called as the acoustic center. The distance between the acoustic centers, therefore, is even longer than the distance between the diaphragms. As a result, it has been found that cancellation occurred between the two loudspeakers at 400 Hz where the distance between the two layers is similar to the half-wavelength. This cancellation makes the sound field control system inefficient and sensitive to the positioning errors of the loudspeakers.

This study aims to develop a pair of loudspeakers that have a short distance between the acoustic centers. In order to have a short distance between the acoustic centers, the diaphragms of the loudspeakers should be located in a short distance. Since the loudspeakers are omni-directional at low frequencies, there can be several arrangements of a pair of loudspeakers. For example, the loudspeakers can be located side by side so that the distance between the acoustic centers is reduced to the width of the enclosure, or the loudspeakers can be turned toward each other. However, additional diffractions are expected due to the enclosure of the other loudspeakers. The position of the acoustic centers can be shifted depending on frequency, or the radiation pattern can be changed in near-field as well as far-field. Hence, this study has two objectives; one is to investigate the effect of the additional diffraction, and the other is to propose a pair of loudspeakers considering the effect of the diffraction. Several arrangements of the pair of loudspeakers are examined, and the effect of the additional diffraction is shown in terms of the change in the radiation pattern and the position of the acoustic center. The boundary element method is used for the simulations where the velocity on the diaphragm of a loudspeaker is measured by a laser vibrometer, and the enclosure of the loudspeaker is assumed to be rigid for simplicity.

In conclusion, this paper shows the development of a pair of loudspeakers that has a short distance between the acoustic centers at low frequencies where the loudspeakers behave as monopoles. The effect of the additional diffraction due to the enclosure of the other loudspeaker is considered. It is expected that the performance of sound field control can be improved by realizing the double-layers with these pairs of loudspeakers.